AMRAD NEWSLETTER

Amateur Radio Research and Development Corporation

~~September~~ OCT 1981

AMRAD MEETINGS for the next three months line up as follows:

October 5 will provide an opportunity for Terry Fox, WB4JFI to speak on television receive only (TVRO) earth terminals for the home. Meeting time is 7:30-9:00 P.M. at the Patrick Henry Branch Library, Vienna, VA.

October 16-17 is the ARRL Amateur Radio Computer Networking Conference at NBS and Goddard. See details inside this newsletter. *The AMSAT annual meeting will be on the evening of October 17, at Goddard. If you are planning to attend, please let AMSAT know so they can make reservations for dinner.*

November 2, a regular AMRAD meeting, will be devoted to discussing the results of the October 16-17 conference.

December 7 is the AMRAD annual meeting.

January 4 will be a talk on viewdata and TV captioning for the deaf by George Lemaster. An interpreter will be provided for the deaf. Deaf members wanting information on how these systems work should not miss this meeting. Visitors are always welcome at AMRAD meetings.

DIRECT ACCESS TO THE FCC Commissioners will be offered October 7, when the FCC reinstates its "en banc" open meeting policy. The en banc meetings were begun under former Chairman Dick Wiley in 1975, in order to provide concerned parties with an opportunity to express to the full Commission their views on communications policy matters.

Anyone Interested In Participating in the October 7 meeting should write William Russell, Director of Public Affairs, Room 202, 1919 M Street NW, Washington, D.C. 20554 with a brief outline of the topic(s) he wishes to present. Participation will be limited by the time available.

The Meeting Will Run from 9 AM to noon in Room 856 of the Commission's 1919 M Street Offices. Thanks *HR Report*.

AMRAD WELCOMES THE APPOINTMENT of James McKinney as Chief of the FCC Private Radio Bureau. We look forward to a good relationship with Jim in his new job. We also bid farewell to Carlos Roberts and thank him for his cooperation in working with us on the spread spectrum special temporary authority (STA).

COPIES OF THIS NEWSLETTER will be available at the October 16-17 conference. For those of you who are not AMRAD members and familiar with our projects, this issue will give you a fair idea of what we do. If you are not a member, we invite you to join and become active in one or more of our projects. Pick any field (packet radio, spread spectrum, handicapped communications, etc.) and you will find tremendous opportunities to make a significant contribution.

AMRAD meetings in Vienna, VA are a smorgasbord of technical talks and demonstrations. Except for the annual meeting in December of each year, regular meetings are exclusively for the topic at hand. We believe that people come to hear the speaker, not endless debate over a petty cash expenditure. A number of members outside the Washington, DC area have written us to say that they wish that they could attend the meetings. A few of the meetings have been videotaped, but editing and distribution have not been worked out to our satisfaction. We have also had some inquiries about establishing AMRAD chapters. We're interested in following up.

AMRAD's underpinning is the experimenter. Nearly all of our members are radio amateurs, but the same can be said for computer amateurs. We don't collect these statistics, but we believe that the majority of our members are also professionals in the communications/computer fields. One problem with some experimenters is that they build some great stuff in the corners of their basements but don't bother to tell anyone else about it. The *AMRAD Newsletter* is interested in receiving manuscripts, design notes, program listings, or what have you, for publication. If you can't turn out a smooth manuscript, send it in anyway. If it's useful to the experimenter, we'll find a way of cleaning it up. If you have no time to write a description, just drop us a line saying what you've done and how to contact you by letter or by phone. We can include this info in the newsletter so people who are interested in your project can reach you directly.

SEE OCTOBER QST p.28, "The Making of an Amateur Packet-Radio Network," by Dave Borden, K8MMO and Paul Rinaldo, W4RI, intended as a tutorial on packet radio.

THE DEAF AND THE TTY

Barry Strassler
Executive Director
Telecommunications for the Deaf, Inc.
814 Thayer Avenue
Silver Spring, Maryland 20910
301-589-3006

AT&T's BOMBSHELL GENEROSITY

On August 21, 1981, AT&T filed a tariff with the Federal Communications Commission (FCC) to reduce interstate rates for hearing and speech impaired customers that use TTY/TDDs for long-distance calls from a residential phone. These rates would be effective on October 30th.

The deaf leaders, myself included, were pleasantly surprised by this announcement. We have agreed to wait for the official transcript of this announcement before filing comments, if any, with the FCC. One thing we have agreed was not to kill the goose that has laid the golden egg.

In February 1979, when I started work as the executive director of the above-mentioned organization, I knew very little about telecommunications matters. But in order to survive, I had to learn fast. And I hope that I did. At any rate, the deaf community was very excited about the intrastate rates breakthroughs in the states of New York and Connecticut. These two states were the forerunner of what was to come in the months ahead. I then made both the interstate and intrastate rates reductions one of my top priorities.

It was very interesting to observe the reactions of the telephone and telecommunications people when this subject was brought up. I was scheduled to give a short speech on one matter at the FCC headquarters and I was instructed by one FCC official not to bring up this subject. I spoke to another FCC official, and he said (at that time) that the FCC was opposed to AT&T's offering reduced interstate rates based on their present technology. I asked why? He said that this technology was obsolete and for all practical purposes would be very inefficient from a cost point of view. He wanted to see AT&T upgrade their equipment first before such thoughts of interstate rate reductions could be entertained. Then a few days later, I bumped into an old friend of mine who works at the AT&T headquarters in New Jersey. I related to him, leaving out names, what the FCC man told me. My AT&T friend was livid with anger, saying that the FCC allegations were totally absurd and that their technology is as modern as it could be. I then asked him how we, the deaf, would go about getting these interstate rates reduced. He didn't know.

On the intrastate level, some states were very eager to grant these to the deaf, while in other states, the public utility commissions were adamant on preserving the status quo. It was so easy in Maryland and in Virginia. The state officials decreed intrastate reductions before we had a chance to make the first move. But on the other hand, some states such as Ohio and Illinois proved to be very stubborn, repeatedly turning down requests by the deaf for these reduced rates. California seemed to be so wrapped up with their "free TDD" program to give attention to other needs of the deaf. And bear in mind that California is a very big state, and it is no laughing matter when a deaf person residing in San Diego places a long-distance call to a friend residing in Dorris, which is just next to the Oregon border.

Presently, there are 36 states with reduced intrastate toll call rates, up from two only two years ago. And the momentum was rolling as deaf leaders in the other states were clamoring for these privileges.

Why would the deaf need reduced rates? The average speed of the spoken word is 120 words per minute. A highly competent typist would type at 60 words per minute. Not every deaf person is a high-speed typist; many of them type in the traditional hunt-and-peck fashion. Assuming that a person types very slowly via the hunt-and-peck system and his speed is ten words per minute then the ratio would be twelve to one. And, if one has to suffer a twelve-to-one ratio on his long-distance phone bills, he needs relief one way or another.

This is indeed a surprise but a very welcome break for us.

□

PROTOCOL

David W. Borden, K8MMO
Rt 2, Box 233B
Sterling, VA 22170
703-450-5284 (Metro No.)

NEWS

The local AMRAD packeteers have been testing the latest software fixes from Doug Lockhart, VE7APU that appeared in the newsletter (*The Packet*) from Vancouver. The fixes appeared to have worked on some bad problems and introduced others. The cw i-d no longer ran at the proper time due to bits being clobbered in Fix No. 7. That took four days to find. Cliff, W4CQI and Bill, W4MIB are busy documenting new problems. It appeared at first that Cliff had some bad RAM on his Terminal Node Controller (TNC) board. Jim, KA9GCS was visiting from Norfolk and helped me write a memory-test program that runs in the fourth PROM. I transmitted it to Cliff (with only one typo) by packet in hex dump form. Cliff burned a PROM, and afterwards we found the bad byte. It worked. But, alas it found only good RAM. That puts the problems back onto the software. I am carefully trying to document the various quirks that have showed up. I am trying to find some consistency. The same problem appearing at W4CQI should also show up at W4MIB and K8MMO.

Sandy, WB5MMB is making great progress on the single-frequency packet repeater. He has received the crystals for it and has built some control circuits. As has been mentioned before in this column, a single-frequency repeater looks exactly like a normal packet station, but with different software installed. Sandy is including a timer so that a "forever packet" is not allowed to hog the channel. The forever packet was a bad condition that existed in the last cut of software. For no apparent reason, the Request To Send (RTS) line would go high (turning on the transmitter), and garbage data would ensue until reset of the TNC board. The latest fixes solved that problem, but Sandy is taking no chances.

Hal, K6HWJ has developed some software mods for the TIP program which allow data transparency. In one of our AMRAD packet informal conferences in my basement, we conjectured that transparent data was a requirement for networking. Currently, certain ASCII control characters are trapped (i.e., control-X, Control-Y, etc.), and certain actions (connect, disconnect, etc.) take place based on the character trapped. This will never do when we move to higher network levels where the consumer assumes that he may send any data with impunity. I will be receiving these latest mods soon and will be testing them with the local packet gang. With the addition of the data transparency mod and several others that I want to sneak in, the TIP software will be at a stage where we can leave it and move on to network software running in the station node. Probably if we cannot solve the remaining bugs in the LIP software, we will drop back two software levels to the LIPM as originally received from Hank, KA6M. That LIP worked acceptably and has received a lot of testing in the Bay area of San Francisco. We certainly want to freeze the software (baseline is the current industry buzzword) as soon as possible to move on to bigger and better projects... the network, for instance.

Hank, KA6M reports that the San Francisco gang is ready for hf schedules. Bill, W4MIB is ready also, and perhaps they can get together soon. Hank says that the addition of a computer to their local area node attracted lots more users. We will be looking into doing that just as soon as the LIP software is super reliable.

It should be noted that the Canadian postal strike is over, and once again the VADCG boards are available. I received two, with promise for more soon. We have made 5 VADCG modem boards (Bell 202 standard) and will be building those up and reporting on their working. The availability of inexpensive modems is important to the overall effort.

I received two Western Digital WD1510 ALPHABETTER buffer register chips to play with. The advertising campaign for this LIFO/FIFO 9-bit-by-132-word memory buffer is a work of art. The chip comes packaged in a soup can (condensed). They claim that it makes CPU-to-printer/terminal buffering "duck soup." The uses for this chip on a TNC board seem obvious. Maybe it is not so obvious after design begins, but it seems possible as a candidate for terminal/computer buffering where the 2114 RAMs are used now. It is certainly worth investigating.

continued→

NETWORK IDEAS

It is past time to think of how we are going to implement the AMNET packet radio network. Out network conference in October is a *must* for people interested in this sort of thing. At our latest AMRAD meeting, a planning session for the conference, we discussed what the AMRAD position, if any, should be. I pushed for an adaptive routing scheme. Briefly, adaptive routing is allowing a new node (network smart station) to enter the network by coming up on the appropriate frequency and sending a ROP (Radio On Packet). When another node hears the ROP, it enters the new node into local tables that it keeps of what nodes it can work (hear) and transmits the tables to its nearest neighbor. I believe that we can implement this sort of thing with some software difficulty which should prove well worth the trouble.

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BOOK REVIEW: John Wall Miller, W4FRW

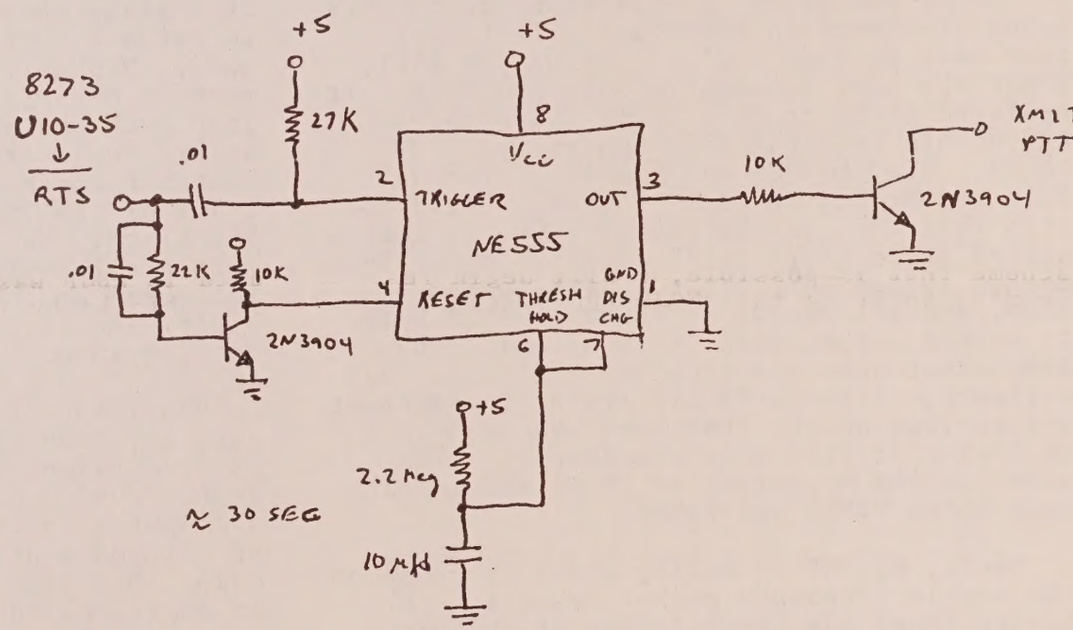
"Understanding Communications Systems," Texas Instruments Learning Center, 1980, Radio Shack, $2.95.

This is a real find. The book is a stand-alone overview of communications systems. It is eary to read or use, interesting, pertinent, well organized and inexpensive. It will provide some help to even the old pro by filling in a gap or so of knowledge, or helping simplify his ability to explain. Recommended for all.

"Understanding Computer Science," Texas Instruments Learning Center, 1981.

What is said for the above book holds for this one too. I find this useful in helping me to regroup my thoughts from many years into an up-to-date set. It ties things together in a refreshing way.

THIS TRANSMIT WATCHDOG timer for the VADCG Terminal Node Controller (TNC) was sent to us by Hank Magnuski, KA6M. The timer in this schematic drops the request-to-send (RTS) PTT circuit if held on for more than 30 seconds. This feature is required for repeaters and other unattended stations. (The 2N3904 transistors are not critical. Any NPN will do.)



MOTOROLA TECHNICAL TRAINING COURSES may be of interest to some of our members, especially those whose employers can pick up the tab. Fees are $295 for 2-day courses and $375 in Phoenix ($430 in other locations) for one student. Write or phone Ron Bishop, Motorola Technical Training, Mail Drop TOM-57, P.O. Box 2953, Phoenix, AZ 85062. Here are courses of possible interest:

MTT1 4 Days Basic M6800 Family

Phoenix, AZ	Oct 20-23, Nov 17-20, Dec 1-4
River Edge, NJ	Oct 20-23
Seattle, WA	Nov 17-20
Boston, MA	Dec 1-4
Houston, TX	Dec 15-18

MTT3 2 Days MC6809 Update

Houston, TX	Oct 20-21
Dallas, TX	Oct 22-23
San Jose, CA	Nov 10-11
Denver, CO	Nov 12-13

THE GEORGE WASHINGTON UNIVERSITY is running the below short courses, in Washington, DC unless otherwise noted:

Dec 02-04 Frequency Synthesizers
Dec 07-10 Japanese Methods for Productivity and Quality, Atlanta, GA.
Jan 04-07 Ditto, New Orleans, LA
Jan 04-08 Data Communications Systems and Networks.

Contact Continuing Engineering Education, GWU, Washington, DC 20052, 202-676-6106 or 800-424-9773.

THE NRI ALUMNI NEWSLETTER "Ham News" column by Ted Beach, K4MKX, July/August 1981 issue gave AMRAD and a number of our projects a nice plug. It also describes AMTOR and coherent cw in which some AMRAD members are involved. Also, NRI has a new Electronic Design Technology course. Write NRI Schools, McGraw-Hill Continuing Education Center, 3939 Wisc Av, Washington, DC 20016.

More on the W9JD FEC System

Jerome T. Dijak, W9JD
215 Tareyton Drive
Ithaca, NY 14850
607-257-3909

My primary purpose in this article is to describe in more detail how my forward error correction (FEC) scheme operates (see the August 81 *AMRAD Newsletter*). In response to my notices in this newsletter and the Digital Group users newsletter I have heard from about 10 hams with computers (four of which are identical to mine) who are interested in this project.

Since I wrote the last article, I have finished the first prototype of the software system. As far as I can test it without another computer for it to "talk" to, it seems to be functioning. (After spending about four weeks identifying and exterminating bugs, I might add.) By the time that this is printed, I hope that some other stations will have gotten systems operational for on-the-air tests.

I have decided that this scheme needs some sort of concise name so that it can be identified without references to cumbersome phrases such as the "twice-interleaved Reed-Solomon (15,9) coding scheme using asynchronous fsk." Recognizing that this is not the only possible forward error correcting scheme that is possible, I will begin referring to it as the "W9JD FEC System."

The Plan

When I wrote the first article, I was not sure of the best course to proceed. Because I found several interested amateurs with computers identical to mine, I have decided to take the fastest course, which is to develop a prototype for the software system entirely myself, and then distribute the machine code to these hams first and conduct initial tests.

After running the prototype system for a while with several different stations, we should learn a lot about which of my ideas were sound and which were not. Then, after making minimal needed changes to get a basically effective system, I will stand back from the experimental work for a while and write some detailed documentation on how the system works. This is to help other people, with other computer systems, to develope compatible software for their own systems. Much of this will probably be in the form of articles in the *AMRAD Newsletter*.

System Operation

At this point, I would like to discuss in general terms the architecture of the software. A simplified diagram of the system is shown in the figure. As may be apparent from the diagram, all things revolve about the four buffers.

One of the important distinctions of this system, as opposed to current computerized RTTY systems, is the concept of a RCV and XMIT state for the keyboard/video display system (I/O) and a separate RCV or XMIT state for the computers and radios. When the system is operating in "ARQ Mode" (acknowledging good blocks and retransmitting bad ones), the I/O devices will go from RCV to XMIT mode on operator command. However, the computers (and radios) will be controlling themselves. (This makes the software rather "interesting" to design and debug.)

Because of this distinction, we can discuss the leftmost portion of the diagram separately from the remainder. On the input side, when the I/O is in XMIT mode, the operator can load data from the keyboard or recall files from the present file system. In both cases, data is loaded into the XMIT buffer (XBUF), for later coding and transmission by the system.

When the I/O is in RCV mode, another software module transfers data from the RCV buffer (RBUF) to the video display. The data in RBUF was assembled from error-free data blocks by the receiving software.

Now let's discuss the encoding and transmission process. The XBLKR (Transmit Blocker) module peridocally checks XBUF to see when data is ready to be "blocked" and coded for transmission. When it finds 7 characters ready, it takes these, computes a sequential block address, adds that to the block, and then calls the ENCODER. The ENCODER computes the 6 check bytes given the 9 bytes already loaded. This block of 15 bytes is then loaded into EBUF (the Encoder Buffer), which holds full blocks for later transmission. When the computer system goes into the XMIT mode, it begins sending the blocks that it finds in EBUF.

For the receiving process, characters received from the demodulator are formed into a block and passed to the DECODER once a 55H start flag is detected. The DECODER checks the block for correctness and attempt to correct bytes that are in error. At this point, blocks that could not be fully corrected are usually discarded, and the system prepares to receive the next incoming block. When the DECODER is done, the RBLKR (Receiver Blocker) module looks at the address field of the block to see if it is a data block, idle frame, or acknowledgement block. Each of these types of blocks must be handled differently.

In the case of a data block, the data is loaded into DBUF (the Decoder Buffer) in block address sequence to build up the

complete message. The buffer is necessary because all blocks may not be correctly received on the first try; there may at first be "holes" in the "message" that must be filled in by later retransmission of some blocks by the other station.

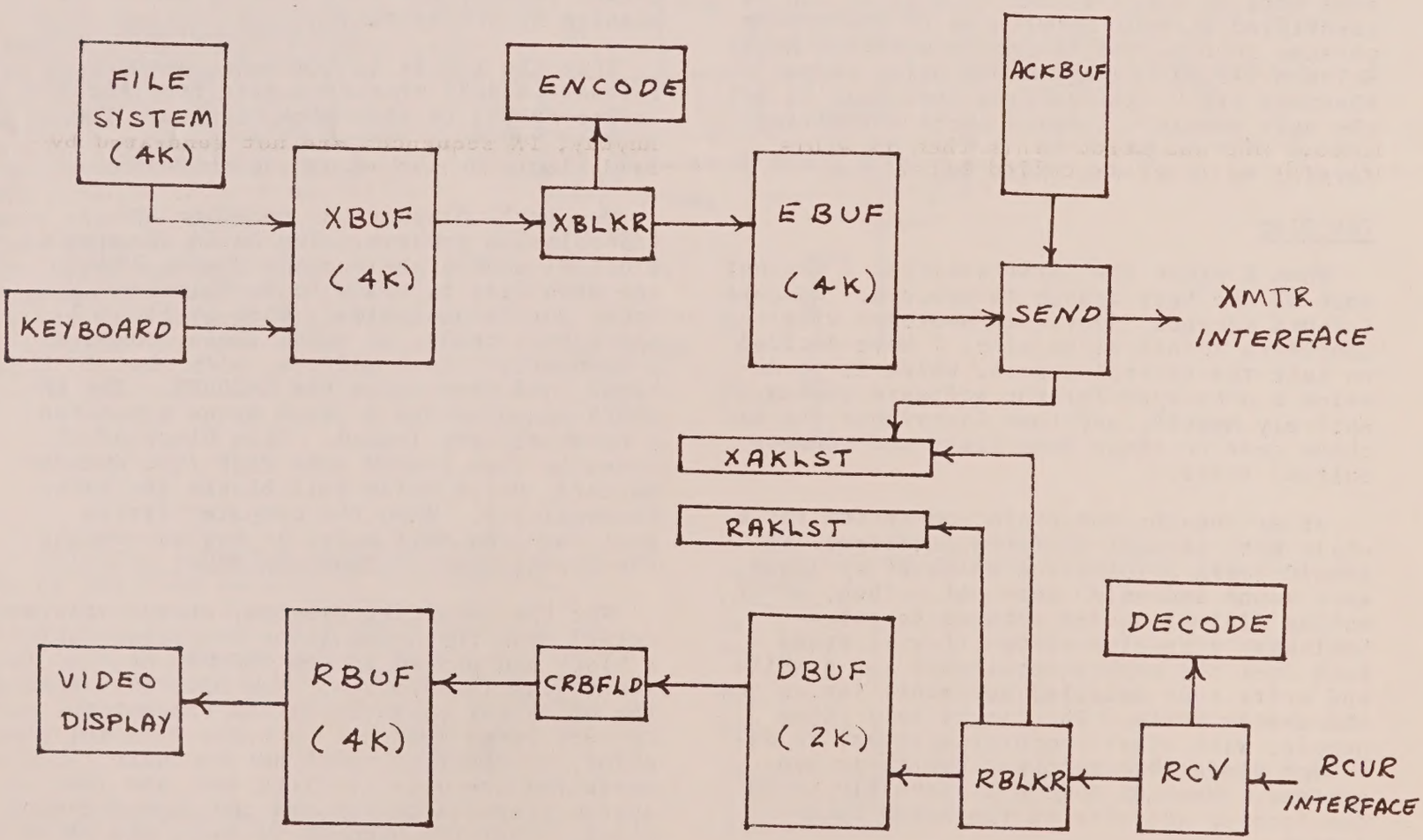
Periodically, the CRBFLD (Consecutive RBUF Load) module checks DBUF to see if any sequential blocks are ready to be transferred to RBUF, and does so when possible.

When Station B successfully decodes blocks sent by Station A, B builds acknowledgement blocks (ACKBLKs) to acknowledge those blocks that were received error-free or were fully correctable. These are then sent back to Station A. (ACKBLKs contain the block addresses of blocks that were decoded successfully.) When Station A receives these ACKBLKs, they are trapped out in the RBLKR module and used remove block addresses from the XAKLST (XMIT ACK List). This list is formed by the transmitting station when blocks are sent, and is used to identify blocks that have not yet been received correctly by the other station. Every block still in the XAKLST is also retained in EBUF for retransmission during the next transmit period.

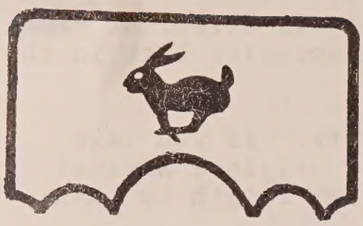
It is nice to always keep the channel active in one direction or another, even when there is no data to be sent. During these times (which should be rare) a special idle fram is sent. This serves to keep the sending software active,and the receiving software just ignores the block. Once real data is available to send, no more idle frams are sent.

Another function performed by the RBLKR module is to take each data block received correctly and put its block address on the RAKLST (Receive ACK List). These block addresses are used to build up ACKBLKs to be sent to the other station later. Also, it insures that the blocks are not loaded into DBUF twice, even though the sending station may send them several times.

In future articles I plan to discuss the detailed protocol used for handshaking, some explanation of how the coding and decoding operations work, and some words on why I chose the particular code and block length that I did. □



W9JD FEC Software System



SPREAD SPECTRUM

Hal Feinstein, WB3KDU
1410 Rhodes St. North
Arlington, VA 22209
703-524-9116 home

Codes are an essential part of spread spectrum (SS) communication systems. In fact, many of the more interesting qualities of SS can be traced to properties of the code used. With so many important features dependent on proper selection of a code a closer look may be useful.

Many of you know that a good SS code must be "random" and have good "cross-correlation properties," but what do these terms mean?

A code may be thought of as a string of numbers generated by some process. In the case of SS we will consider only strings of numbers in which the numbers assume two values: one and zero. This then is a binary code with digits called bits.

Many processes can be used to generate a binary stream of bits. They can be divided into two kinds. First the bit stream may be random. That is there is no way to predict from a knowledge of the generating device or its past output what the next value it produces will be. This is a critical requirement for a truly random stream.

If you stop to think about it you'll find that any machine that you devise to produce truly random numbers (bit streams in our case) must have a source of *natural randomness* in it. Natural randomness means that the noise from a diode or the time that the next particles will be ejected from the nucleus of a radioactive atom are random. Why? Because no one has yet devised a way to calculate the values for these quantities.

There are a number of uses for pure randomness such as cryptography, simulation and measuring the characteristics of a communications system, but not in spread spectrum.

SS requires that both the transmitter and the receiver must have a copy of the random bit stream to command the synthesizer or modulate a direct spread carrier. This brings us to the next type of randomness which is not really random. In fact, this is a basic problem which mathematicians ran up against in defining randomness. Our first type of randomness uses a pure natural random source. We would expect it to pass any tests originally devised to check randomness, and it does. But, mathematicians also discovered a type of process which produces a stream of numbers which pass these randomness tests as well!

To this second type of randomness, the term "pseudo-random" was created. Another popular name in engineering circules which arose because pseudo-random numbers look so much like noise is "pseudo-noise" or PN sequences.

Anyway, PN sequences are not generated by a purely natural random source but by a physical device which has well understood rules. What is this magical device? It is the shift register hooked up as shown in Fig. 1. This little circuit implments what mathematics people call a recurrence system because some of the output is fed back to generate the next input. Thus the output continually is fed back and "recurs." You will also find this circuit called the linear feedback shift register (LFSR) because the two taps taken on the third and fifth cells are combined using exclusive-ORing (a linear operation) and then fed back.

Just as an aside from our main topic there are two more-or-less familiar uses for recurrent systems that amateurs may have bumped into: (1) *Fibinocci* numbers generated by the equation:

$$F_n = F_{n-1} + F_{n-2}$$

$$\text{Next} = \text{Last} + \text{Next-to-last}$$

This simply says take any two numbers for F_{n-1} and F_{n-2} starting values. Then add them together to find F_n. To continue, use the current value of F_{n-2} as your output then $F_{n-2} \leftarrow F_{n-1}$; $F_{n-1} \leftarrow F_n$. Repeat this loop by performing the next addition. Keep going; you are producing Fibinocci numbers! Fibinocci, by the way, got these numbers named after him by cleverly solving a problem in which you put two rabbits in a cage and come back to count the number of offspring some

time later!

As fate would have it, forms of Fibinocci number generators are the heart of most computer "random" number generators. These types of algorithms are one of the best known uses of Fibinocci numbers.

(2) *IC noise generators* - Some manufacturers have recently produced an IC chip which acts as an audio noise generator. The internals of the chip use a feedback shift register to produce noise-like voltages.

Now let us return to our discussion of SS codes. Because the shift register will be our generating device for these codes, what are some of its properties?

1. A shift register sequence repeats after a fixed number of outputs. The largest you can get this number to be is related to the feedback taps and the number of cells. The longest possible is found by length = 2^{N-1} where N = the number of cells. The taps must be connected to form a *maximal* sequence. Some maximal tap settings are given in Table 1.

2. A given maximal connection setup will produce a single long repeating sequence. A non-maximal setup will produce several sequences, depending on the initial load (called the *seed*). The summed length of all these shorter sequences will be equal to the length of a maximal sequence with the same number of shift register cells.

3. (For mathematicians only) How many maximal tap connections are there for a given size register? Answer is related to an important idea in mathematics called Euler's phi function (pronounced OILER's). Let us skip the calculation step and just list a few results:

# of Stages	Possible Maximals	Length of Sequence	Sample Maximal Taps
2	1	3	1,2
3	2	7	2,3
4	2	15	3,4
5	6	31	3,5
6	6	63	5,6
7	18	127	6,7
8	16	255	4,5,6,8
9	48	511	5,9
10	60	1023	7,10
15	1800	32767	14,15
20	2400	1048575	17,20

Table 1.

The table gives the number of stages in the shift register, the number of different tap combinations which will produce a maximal sequence, the length of the longest sequence for that number of register cells and one maximal tap setting for each value.

4. N-Run Property. For a maximal sequence generated by a N stage LFSR, every run of N consecutive bits is different from every other run of N consecutive bits in the sequence.

5. Decimation property. If you take every jth bit out of the original maximal sequence which has maximum length L, then:

(a) if j (the sampling rate) cannot divide L without leaving a remainder the new sequence formed by selecting every jth bit out of the initial maximal sequence will also be maximal.

(b) if j is an odd number and can divide L without leaving a remainder the new sequence will be nonmaximal.

(c) if j is an even number and can divide L without leaving a remainder, then the resulting sequence will be a shifted version of the original.

6. Impulse response property. For a nonmaximal setup several different sequences will be produced. One of these sequences will be longer than the others. This sequence can always be produced by loading the initial seed to be all zeros except for the first or last cell which is set to 1. Now the length of any of the smaller sequences will always divide the length of this biggest impulse response sequence evenly.

7. Superposition property. By detailed mathematical analysis it can be shown that every nonmaximal sequence is composed of the exclusive-OR of several small maximal length sequences.

8. Cycle property. Because every sequence repeats itself after a given number of times, it is called a cycle. If any starting position of this cycle is chosen, the shift register will continue generating values which normally come next in that cycle. This is known as a phase difference because it is very much like choosing a sine wave at some advanced phase position on its curve. For example, in Fig. 3 if we select a value at random, say 26, and put this value in the generator, the generator will pick up by producing the next values which are 13, 6, 19 and so on. The same values are produced over and over again but from a different starting point.

Correlation techniques are essential tools in the study and characterization of random processes.

To understand some of the properties which SS derives as a result of using a coded carrier, we need to examine some correlation tools.

Basically correlation is the idea of determining how much likeness one set of data has with another. Correlation usually is measured between -1 and 1. These values have a well defined meaning.

continued→

Correlation Output	Properties
1	The first sequence matches the second sequence exactly.
0	There is no match at all between the two sequences.
-1	The two sequences are mirror images of on another.

Correlation can take on any value between 1 and -1, and that value can be used to measure likeness of the two sequences.

One interesting form of correlation is when you correlate a sequence with all phase shifts of itself. This results in a table of correlation values for the different shifts. This technique is called autocorrelation and is one of the tests used to measure how random a given sequence is. Pure random data should have a correlation equal to 1 for a perfect match with itself and a value close to zero for all autocorrelations with a phase shift other than zero. It turns out that most shift register sequences have this property and so pass this test for random data even if they are deterministic.

Correlation must always be done against two batches of data, to tell how much one is like the other. For autocorrelation, the same batch is measured against all phase shifts of itself. This results in a table of values, one value for each phase shift.

Crosscorrelation is a tool which measures the likeness of two sequences. One is considered a reference copy, while the other sequence will undergo various phase shifts. Like the autocorrelation, crosscorrelation results in a table of values, one for each phase shift of the nonreference sequence.

As we progress in our study of spread spectrum codes, we will see that crosscorrelation forms the heart of many SS properties. Codes are studied and chosen based on low crosscorrelation properties. Because the SS carrier is coded, the carrier takes on similar crosscorrelation characteristics. In fact, crosscorrelation is used by some SS receivers to choose or reject the properly coded carrier.

A very useful tool for measuring goodness of a sequence is the crosscorrelation function. This tool is easy to calculate and what it does is to report on the likeness of one sequence with another for <u>all</u> phase shifts.

This process can be done by this procedure:

1. Line up the two sequences, one under the other.

2. Find the number of places that the lower bit matches the upper bit, count these and save the count in a table.

3. Now shift the lower sequence by sliding it back one position and bring the last bit up to the front.

4. Perform steps 2 and 3 until the entire lower sequence has been shifted all the way around. The table you build by this process from step 2 is the output and result.

How can we use these tools to discover properties of SS? Let's examine some of the important properties of SS:

1. <u>Interference rejection</u>. The action of a SS receiver is like the crosscorrelation process described above. The receiver has a locally generated copy of the code which the transmitter also is using. Signals which don't look like the code are averaged out by the correlation process. This includes noise, cw and fm signals or other SS setups using a different code. If the code is secret, then jamming will also be reduced because the jammer cannot determine the code used.

2. <u>An abstract channel</u> (code multiplexing). A code can be considered as a channel because the correlation action is interested in receiving only the signal with the same code it has. Two users each using the same code can talk to each other. Different codes are rejected.

3. <u>Privacy</u>. Because receiving an SS signal requires that the receiver know the code, specially chosen codes can provide privacy channels.

4. <u>Overlaying</u>. There is a theoretical ability to overlay other users with wideband SS signals. To the conventional user, the SS signal would appear to be noise because of the random property of the PN streams. The less randomness a code shows, the more signal energy starts to collect in various places in the user spectrum. As randomness goes still lower, the wideband noise signal starts to take on the appearance of a simple high-speed digital signal which will interfere with conventional users.

<u>Conclusion</u>: Codes are essential to spread spectrum for many of its properties. We have listed several of the better known properties and note that many others exist which rely on more advanced math.

Now that the foundation has been laid, the next issue of this newsletter will explain some of the more important SS codes such as the Gold, JPL and M-length sequences.

A good write up on shift registers appears in the TTL Cookbook and CMOS Cookbook, both by Lancaster and published by Sams. □

Figures for Spread Spectrum column:

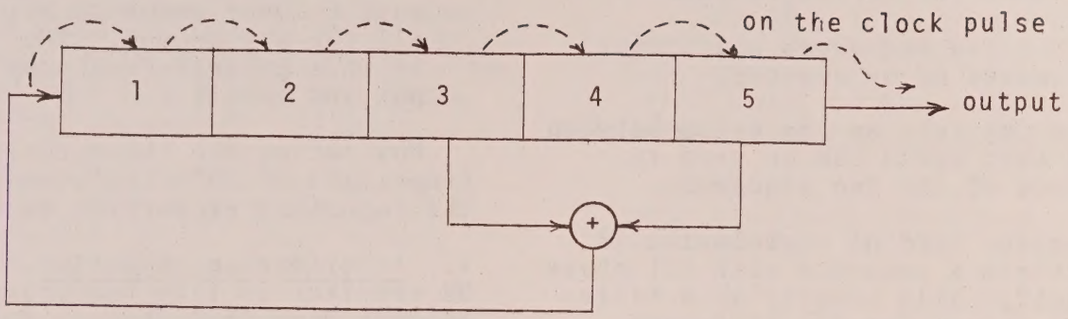


Fig. 1.

1	28	14
16	30	23
8	31	11
4	15	21
18	7	10
9	3	5
20	17	2
26	24	
13	12	
6	22	
19	27	
25	29	

output sequence, maximal, Length = 31, taps = 3 & 5, 5 cells.

Fig. 2.

	$\ell_1=21$	$\ell_2=7$	$\ell_3=3$
1	10	23	27
16	21	11	13
8	26	5	22
4	29	18	
2	30	25	
17	31	28	
24	15	14	
12	7		
6	3		
19			
9			
20			

3 output sequences for a nonmaximal setup of 5 cells with taps at 4 & 5. Notice that $\ell_1 + \ell_2 + \ell_3 = 31$ which is the length of a 5-cell maximal sequence.

Fig. 3.

AMATEUR RADIO RESEARCH AND
DEVELOPMENT CORPORATION
1524 SPRINGVALE AVENUE
MCLEAN, VIRGINIA 22101

ARRL Amateur Radio
Computer Networking Conference

October 16-17, 1981
National Bureau of Standards
Gaithersburg, Maryland

THE ARRL AMATEUR RADIO COMPUTER NETWORKING CONFERENCE will convene at 0900, Friday, October 16, 1981 in Lecture Room A of the Administration Building, National Bureau of Standards, Gaithersburg, MD. This conference will (1) recognize the innovative work already done by Canadian and U.S. amateurs, (2) explore the possibilities of an integrated amateur packet network, and (3) set up the framework for orderly growth of a network.

FRIDAY PROGRAM: (as of September 22)

0815 Pickup of attendees from Holiday Inn, Days Inn and Sheraton Potomac, conference registration open.
0900 Introductions & announcements

GENERAL SESSION

0915 "Amateur Packet Network Agenda," Paul L. Rinaldo, W4RI, conference coordinator
0945 "The 6809 in Packet Radio," Dennis T. Connors, KD2S
1015 "SOFTNET - Packet Radio in Sweden," Jens Zander, SM5HEV
1045 "New Amateur FSK Proposal," Robert E. Watson

APPLICATIONS SEMINAR

1115 "Computer-Controlled Message Handling" Russell D. Ward Jr, WA4ZZU
1145 "Deaf Telecommunications Networking," Barry Strassler, Executive Director, Telecommunications for the Deaf
1215 Forum on network applications
1300 Lunch in NBS Cafeteria

NETWORK ARCHITECTURE SEMINAR

1400 "Network Structure, Protocol and Terminal Control," Douglas Lockhart, VE7APU
1430 Forum on network architecture

LOCAL AREA NETWORK SEMINAR

1515 "On the Care and Feeding of Your Packet Repeater," Dr. Hank S. Magnuski, KA6M
1545 "Throughput Enhancement of a Local Area Single-Frequency Packet Repeater," David W. Borden, K8MMO
1615 "An Emergency and Routine Communication Network for Illinois Using Packet Radio Techniques,"
1645 "Formation of Local Standards in North Jersey Packet Group," Steven Robinson, W2FPY
1715 Forum on local area networks

Friday evening will be open for informal gatherings. Announcements will be made at the Friday daytime session.

SATURDAY PROGRAM (Due to the large number of papers, the conference will continue on Saturday, October 17, at or near the Goddard Space Flight Center. Firm arrangements are being made and will be announced at the Friday session. If you don't attend the Friday session, check the AMSAT 146.235/835 repeater.)

0845 Pickup of attendees from same three Rockville/Gaithersburg motels as on Friday. Drive to Goddard.

SATELLITE DATA COMMUNICATIONS SEMINAR

1000 Welcome, Dr. Tom Clark, W3IWI
1015 "Digital Communications with Phase III Series Satellites," Tom Clark, W3IWI and/or John L. DuBois, W1HDX
1045 Forum on AMICON (AMSAT International Computer Network)

CONFERENCE CONCLUSION

1130 Open forum on amateur radio packet networking. This will provide an opportunity for attendees to add topics not covered earlier in the conference and to put forward proposals and resolutions.

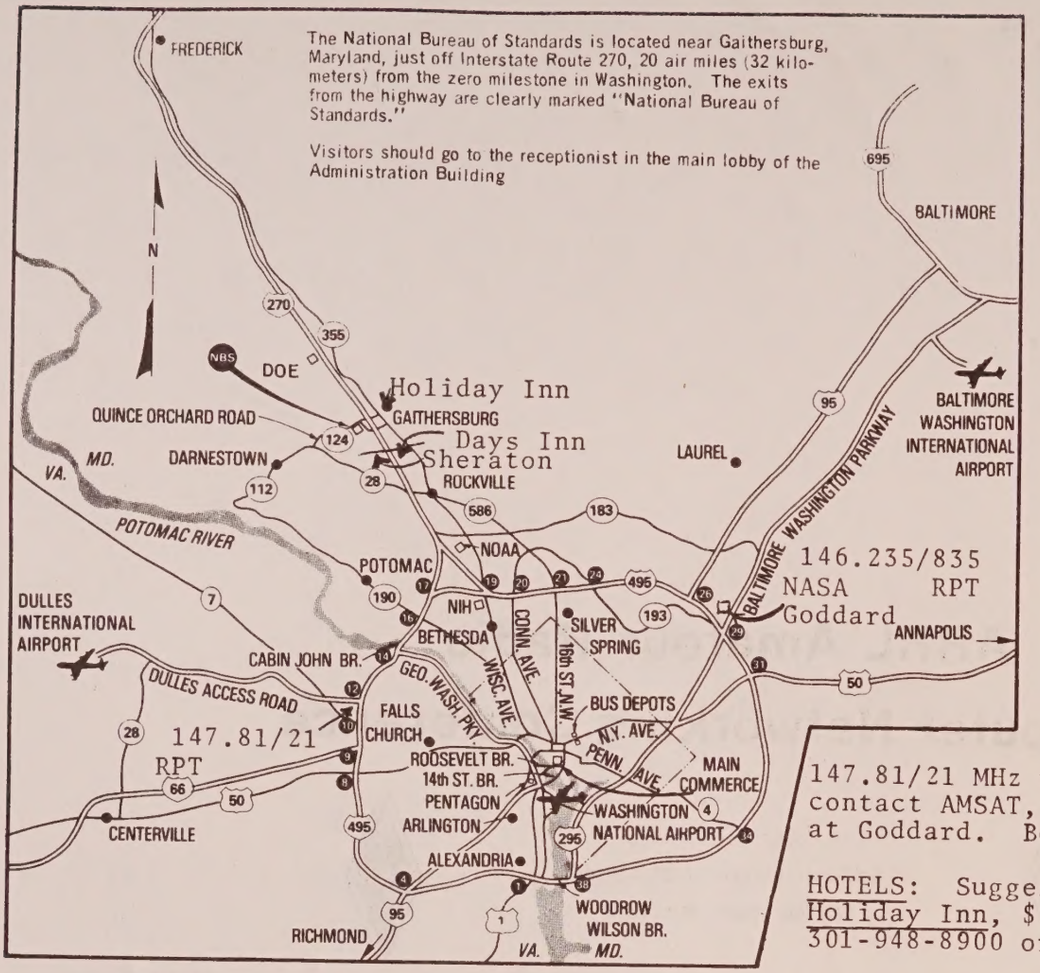
ABSENTEE PAPERS:

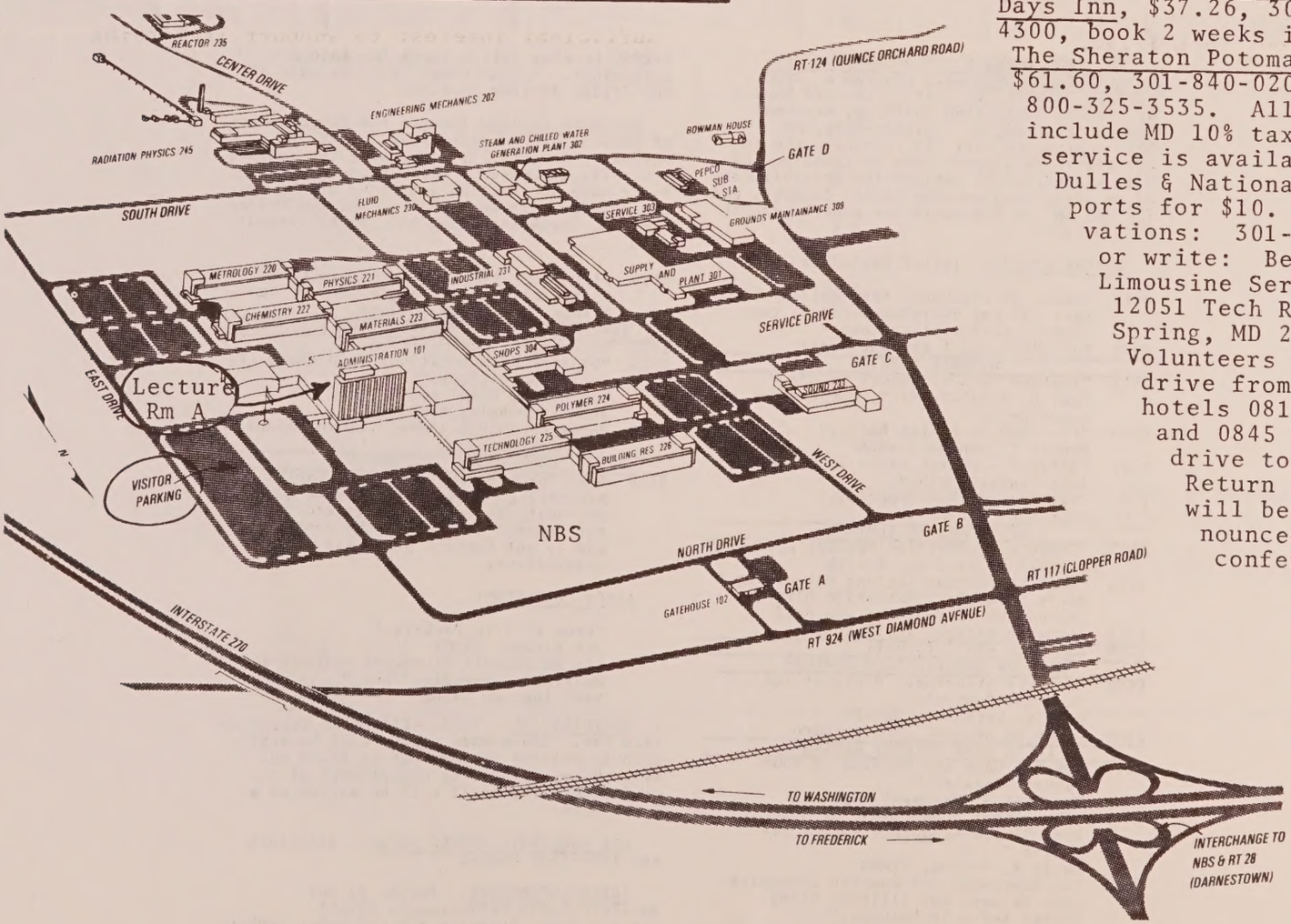
"From RTTY to Packets," Joe Kasser, G3ZCZ
"An Expandable Microwave Network for Multimode Communications," Dave Ingram, K4TWJ

REGISTRATION: There will be no registration fee. Conference papers will be available in printed proceedings at $5.00 per set, Volume I will be distributed at the conference; Volume II will be mailed at a later date.

NBS CAFETERIA COFFEE HOURS: 0930-1015 and 1400-1500 hours.

ACKNOWLEDGEMENTS: Thanks go to:
American Radio Relay League (ARRL)
Amateur Radio Research & Development (AMRAD)
Radio Amateur Satellite Corp. (AMSAT)
National Bureau of Standards (NBS)
Bureau Radio Amateur Signal Society (BRASS).





CONFERENCE: Friday, October 16 0900-1800, Lecture Room A, National Bureau of Standards Admin. Bldg. Park in VISITOR PARKING per map below. Saturday, October 17 1000-1300, NASA Space Flight Center, exact location to be announced. Directions to Godard: Take Baltimore-Washington Parkway to the Greenbelt Rd exit (Rt 193) and take Greenbelt Rd east for 1.5 mi. Saturday afternoon and evening, the AMSAT annual meeting will be held at the Goddard Employee Recreation Center: Turn left off Greenbelt Rd onto Soil Conservation Rd, go 0.1 mi to the first gate you come to on the right. Go through gate and continue to the Rec Bldg.

REPEATERS: If you need assistance, call on the AMRAD 147.81/21 MHz repeater at McLean, VA. To contact AMSAT, use 146.235/835 MHz repeater at Goddard. Both are on map at left.

HOTELS: Suggest Rockville-Gaithersburg Holiday Inn, $57.20 Thurs, $45.10 Fri &Sat, 301-948-8900 or 800-238-8000. Rockville Days Inn, $37.26, 301-948-4300, book 2 weeks in adv. The Sheraton Potomac Inn, $61.60, 301-840-0200 or 800-325-3535. All prices include MD 10% tax. Limo service is available from Dulles & National airports for $10. Reservations: 301-622-0700 or write: Beltway Limousine Service, 12051 Tech Rd, Silver Spring, MD 20904. Volunteers will drive from above hotels 0815 Fri and 0845 Sat and drive to meeting. Return pooling will be announced at conference.

FOR SALE:

TMC QRP transmitting mode selector model 3BE2/exciter unit model A-1515, portable master oscillator, and power supply, 3 pcs w/manual $150.
FSK oscillator, tone intelligence system model TIS 3m w/manual $25.
Open wire remote controlled antenna matching system model HFAS-1 w/manual $75.
Millen scope and amp rack mount w/book $30.
Radio receiver, R-392/URR w/manual $200.
TMC tone intelligence system model TIS 3 $15
P-P 4-125A radio transmitter w/power supply & printed data, 2 pcs $175.
Lambda regulated power supply model 50, 0-500 volt, 800 watt, $25.
Tube tester, TV-3C/U w/schematic $30.
Multi-Elmac w/power supply & book, mod AF67, 80-10, $50.
Frequency meter, FR-67/U w/manual $30.
Conrac video monitor w/manual $125.
Model 35 ASR, friction feed, $225.
Model 35 ASR, sprocket feed, $175.
Double 28 TD, triple case $15.
Triple M28 TD $25.
Triple M28 TD w/manual $50.
Torn-tape system unassembled, mint, w/wd's & manuals $1500.
XT-4 shifter incl receiver/transmitter, digital clock, printed data, $110.
UT-4 w/TX/RX speed converter $125.
Hewlett-Packard 5382A counter, book $250.
Premax stainless steel telescoping vertical antenna w/base $125.
Kleinschmidt typing reperf $35.
Fourteen (14) model 28 typing reperfs only, $12 each.
Box of reperf parts $2.
6-foot rack $7.50.
Used TT parts $5 per box.
Magazines: *CQ, 73, QST, RTTY, Ham Radio* from 1959-79 $2.50 per pack per year.
Six (6) M28 printer frames w/parts plus two misc pcs, all for $10.
Double TD mount, stripped, w/gears $5.
M28 RO cabinet w/base and variable speed motor $10.
M28 RO w/variable speed motor, excellent condition $75.
M28 RO cabinet $15.

FOR SALE: (continued)

Two (2) variable attenuators, CM-575/U, 0-110 dB, dc-250 MHz $10 each.
Driver assembly, part #179560 $50.
Two (2) M28 communication type boxes, used $15 each.
Compact TD $50.
Siemens TD, cover missing $15.
Other misc. items for sale. Send SASE for list to M.e. Nicholson, 4006 Moss Dr, Annandale, VA 22003. Phone 703-256-0716.

CORRESPONDENCE:

I am interested in learning how to combine ham radio and my Z 80 Home Brew Computer, 32k RAM, 32k EPROM for communication. My Model 15 TTY motor governor points are about gone, have tried a SCR but not too much success.

Rig is a barefoot SWAN 400 to 18 HT vertical.

Newell Field, W6TQY
5005 W 130 St
Hawthorne, CA 90250

Ed. Note: It would take a book to really answer this letter. Will someone please try to help Newell get started?

I have been following the AMRAD packet radio work with great interest. A recent issue of *HR Report* noted some Canadian experiments with ANIK-B. This got me thinking of the NASA ATS-6 satellite which I suspect is idle most evenings and weekends. NASA is hungry for applications and justification for their budget so it is quite possible that they would approve amateur packet experiments during idle hours... If there is sufficient interest to support it I think AMRAD should make a proposal to NASA for packet experiments on ATS-6.

73,
George Gadbois, W3FEY
Maple Lane
Lancaster, PA 17601

Ed. Note: George says that he will be at the packet radio conference on October 16. So if you see him, you might want to talk to him about this idea. If not, I'm sure that he'd welcome a letter.

AMRAD **Amateur Radio Research and Development Corporation**

Membership Application/Renewal

Mail to: Gerald Adkins, Treasurer
1206 Livingston St N
Arlington, VA 22205

See reverse for overseas mailing rates.

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Name_____
Ham Call_____ Home Phone( )_____

Address_____
City,
State_____ ZIP_____

Class License_____ ☐ ARRL Member
Have: ☐ 2-meter FM ☐ RTTY
☐ Computer model_____
Microprocessor type_____

I agree to support the purposes of the Corporation.

*Signature*_____

THE AMATEUR RADIO RESEARCH AND DEVELOPMENT CORPORATION is a technically oriented club of about 400 radio and computer amateurs. It is incorporated in the Commonwealth of Virginia and is recognized by the Internal Revenue Service as a tax-exempt scientific and educational organization.

THE PURPOSES OF THE CLUB are to: develop skills and knowledge in radio and electronic technology; advocate design of experimental equipment and techniques; promote basic and applied research; organize forums and technical symposiums; collect and disseminate technical information; and, provide experimental repeaters.

MEETINGS ARE ON 1st MONDAY of each month at 7:30 p.m. at the Patrick Henry Branch Library, 101 Maple Ave E, Vienna, VA. If the 1st Monday is a holiday, an alternate date will be announced in the *AMRAD Newsletter*. Except for the annual meeting in December, meetings are normally reserved for technical talks - not business.

THE WD4IWG/R REPEATER is an open repeater for data communications (including RTTY), voice and experimental modes. It is located at Tyson's Corner, McLean, VA and has excellent coverage. It features a semi-private autopatch available to licensed members. Frequencies are: 147.81 MHz input, 147.21 MHz output. The head of the technical committee is Jeff Brennan, WB4WLW, 7817 Bristow Dr, Annandale, VA 22003, phone 703-354-8541.

THE AMRAD NEWSLETTER is mailed monthly to all members and to other clubs on an exchange basis. Technical articles, new product announcements, news items, calls for papers and other copy related to amateur radio and computing are welcome. Honorariums at a rate of $10 per printed page ($20 maximum per author per issue) are paid for original material accepted. Classified ads are free to members. Commercial ad inquiries are invited. The editor reserves the right to reject or edit any portions of the copy. Items should be mailed by the 8th of the preceeding month to Paul L. Rinaldo, W4RI, Editor, 1524 Springvale Ave, McLean, VA 22101; phone 703-356-8918. Full permission for reprinting or quoting items appearing in the *AMRAD Newsletter* is granted provided that credit is given. Mailing is by 3rd Class bulk mail to U.S. addresses and 1st Class to Canada and Mexico. Overseas readers add 96¢ for surface or $7.80 for air mail to annual dues.

THE AMRAD MESSAGE SYSTEM is an S-100 Computerized Bulletin Board System on 703-734-1387, system operator Terry Fox, WB4JFI. Terry's home phone number is 703-356-8334. The system accepts 110, 300, 450 and 600 baud ASCII callers using Bell 103-compatible modems.

THE HANDICAPPED EDUCATION EXCHANGE (HEX) is operated by AMRAD for those involved in education and communications for the handicapped. It accepts both 110/300-baud ASCII and deaf TTY callers. on 301-593-7033. The sysop Dick Barth, W3HWN's home phone is 301-681-7372.

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THE AMRAD LIBRARY is operated by Tedd Riggs, KC4YN, 8402 Berea Ct, Vienna, VA 22180, phone 703-573-5067. Donations of technical books, magazines, manuals and catalogs are tax-deductible.

AMRAD IS AFFILIATED with the American Radio Relay League (ARRL), the Foundation for Amateur Radio, the Northern Virginia Radio Council (NOVARC) and The Mid Atlantic Repeater Council (T-MARC).

SPECIAL INTEREST GROUPS are formed from time to time. Currently we have SIG's on Deaf Communications and Spread Spectrum Communications. If you are interested in joining or forming a SIG, please contact Bill Pala, WB4NFB, 5829 Parakeet Dr, Burke, VA 22015; phone 703-323-8345.

TRAINING CLASSES are run as needed. Please discuss your training requirements with any Director.

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